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UTILIZATION OF ALMONDS FOR VARIOUS FOOD PRODUCTS

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INTRODUCTION

The production of almonds in the United States has increased materially during recent years, and a further increase is indicated in the immediate future. The domestic crop is at present consumed largely in the unshelled-nut trade, while the large quantity of nuts required for the manufacture of such products as almond bars and almond paste is supplied principally from European sources. Certain varieties of almonds, because of their appearance and the difficulty with which they are shelled, are not so satisfactory as others for the unshelled-nut market, and their elimination from that market would tend toward the standardization of the nuts. While the work described in this bulletin was undertaken primarily to find a means of utilizing such varieties in the manufacture of various food products, some of which are not at present known to the trade, it should be stated that all varieties of edible almonds, whether domestic or foreign grown, may be used for the preparation of such products. The general plan by which these products are derived from the kernels is shown in Figure 1.

In the following pages the several products are considered under separate headings in regard to their composition, keeping qualities, and general characteristics, and the last section deals with methods for their manufacture and the general operation of a factory for their production.

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SALTED ALMONDS

Salted almonds have been on the market for years, but their sale has always been limited, probably because of the high retail price at which they are usually sold, namely, $1.50 to $2 a pound. It seems likely, however, that certain varieties of California almonds not thus utilized at present may be marketed as salted almonds, provided they are carefully prepared, packed, and sold at a reasonable price.

In a general plan for the utilization of almonds, the choicest varieties both as to appearance and flavor should be reserved for the salted-almond trade. In all products in which the kernels are ground the off sizes and less attractive varieties can be used, but salted almonds, especially when packed in glass containers, must present an attractive appearance. In order to insure uniformity it is necessary to grade the kernels carefully according to size. This can probably best be done by picking the choice well-blanched kernels by hand from

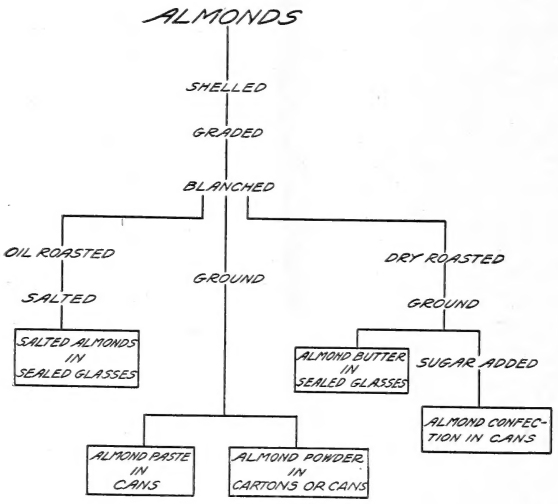

FIG. 1.—Diagram showing the three lines of almond products prepared from blanched almonds

the conveyer belts immediately after they have left the blancher (fig. 2) or by removing the broken and unblanched kernels by hand or by screens.

The roasting is a most important process and must be thoroughly understood and carefully controlled, since it determines the flavor as well as the appearance of the almonds.

It is generally recognized that dry roasting does not develop the best flavor in nuts, and for this reason the best grades of salted almonds and peanuts are roasted by immersion in an oil bath. The temperature of the bath and the time of immersion must be carefully controlled. Almonds roast very rapidly and at a comparatively low temperature in an oil bath. A maximum temperature of 150° C. (302° F.) is generally sufficient, and the kernels continue to darken for a short time after they have been removed from the bath. The kind of oil used is also an important factor. Coconut oil is said to be used extensively in the case of peanuts and may be used also for

roasting almonds. Owing probably to the fact that almonds contain no starch, they absorb the oil which adheres to them after their removal from the bath much more slowly than peanuts and retain a shiny and greasy appearance for a considerable time.

The kernels may be salted by dipping them in a concentrated brine solution and allowing them to drain and dry. This leaves them coated with very fine crystals of salt which adhere firmly. If the salt is merely mixed with the kernels it collects on the bottom of the package and in the case of glass containers the package presents an unsightly appearance.

ALMOND BUTTER

A new product considered well worthy of favor by the public has been designated "almond butter." This consists of ground roasted almond kernels with the addition of a small quantity of salt. Its preparation is very similar to that of peanut butter. The roasting of the kernels for this purpose is best accomplished by subjecting them to dry heat in a revolving drum, as in a peanut roaster (fig. 3). Care must be exercised, since the kernels have a tendency to darken when being roasted, and excessive darkening will give an undesirable color to the finished product. After they have been sufficiently roasted the kernels are rapidly cooled and then conveyed directly to the grinder (fig. 4). Here the peanut-butter machine can be used to advantage. About 2 per cent of salt is slowly added during the grinding process.

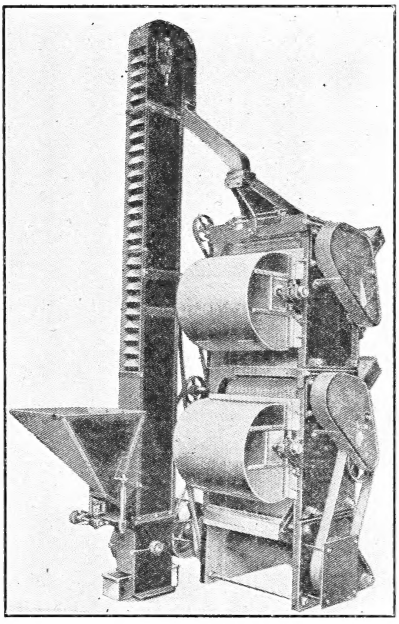

FIG. 2.—Double-capacity blancher and feed elevator

Since peanut butter can be prepared much more cheaply than almond butter, because the peanuts themselves are cheaper, it is desirable to make the almond butter as distinctive in taste as possible. The addition of a very small quantity of the oil of bitter almonds free from hydrocyanic acid—1 pound to 1,500 pounds of the product—imparts a characteristic flavor. This can be included at the same time the salt is added.

Owing to the comparatively high oil content of almonds, the oil has a tendency to separate and to appear on the surface of the prepared butter, and care must be exercised in order to control the quality of the finished product. This can be accomplished by a proper blending of the several varieties of almonds used. However, a product so low in oil content that no oil separates is likely to be somewhat dry. A statement to the effect that the separated oil should be stirred into the product before using could be placed on the label of the finished package.

While almond butter may be marketed in several types of containers, its quality remains unimpaired for a longer time if vacuum-sealed containers are used. Vacuum-sealed glasses of attractive design and attractively labeled would probably be best suited for a product of this type.

ALMOND CONFECTION

Since almond butter, because of its characteristic taste and distinctive flavor, found favor with many to whom samples were submitted, it was thought it could be made the base of an excellent filling for wafers and cakes. Accordingly experiments were made, which

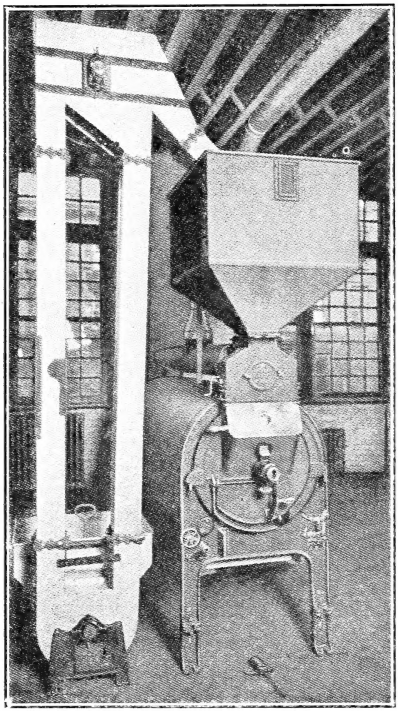

FIG. 3.—Roaster with feed hopper and bucket elevator

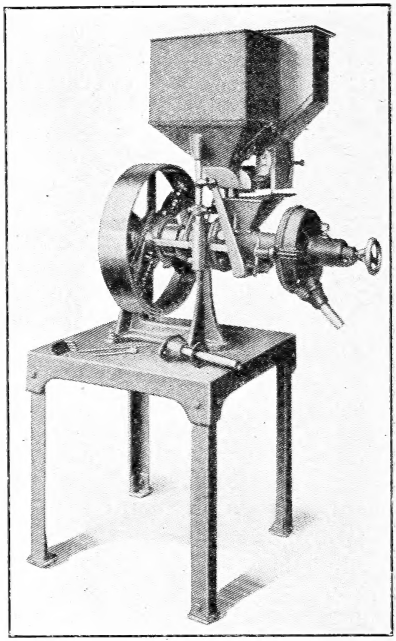

FIG. 4.—Mill for making nut butter

resulted in a product that has been designated "almond confection." Its preparation consists in thoroughly incorporating the ground roasted kernels with confectioners' sugar (fig. 5) in the proportion of 1 part of kernels to 1.17 parts of sugar. The mixture thus prepared is dry and crumbly and must be made into the form of a paste in order that it may best be used for the purpose suggested. This is accomplished by the addition of either water or fixed oil of almonds. Water added at the rate of 1 part to 3.6 parts of sugar or fixed oil of almonds at the rate of 1 part to 10 parts of sugar produces a confection of the desired consistency. Under some conditions the confection made with oil has a distinct advantage over that made with water. If used in products that are baked, the confection made with water becomes

hard and brittle, because of the evaporation of the water during the baking process, whereas that prepared with oil becomes somewhat softer on heating, but on cooling reverts to its former consistency.

The confection should contain about 1 per cent of salt, and to each 100 pounds of the mixture there should be added 1.1 ounces of oil of bitter almonds free from hydrocyanic acid.

ALMOND PASTE

Probably one of the oldest and best-known uses of almonds in the confectionery trade is for the preparation of almond paste, a mixture of ground unroasted kernels, sugar, water, and flavoring, which is used mainly for making macaroons. As early as 1875 a patent was issued in this country on "an improvement in preserve compositions for macaroons," indicating that such a product has been in use in

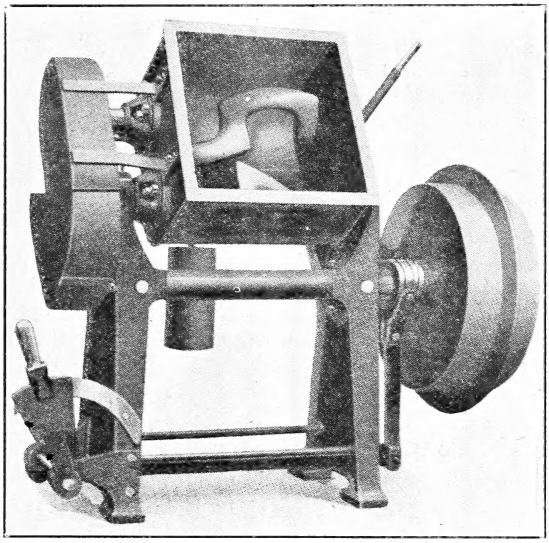

FIG. 5.—Machine for the preparation of almond confection and almond paste

one form or another for many years. It is estimated that from 6,000,000 to 7,000,000 pounds of almond paste are consumed in this country annually, most of which is manufactured by large candy manufacturers and sold to bakers for making cakes and macaroons.

The manufacture of almond paste consists essentially in incorporating finely ground kernels, sugar, and water into a homogeneous mass with subsequent cooking. The exact details of the operation are difficult to ascertain; in fact, it is quite probable that the several manufacturers do not follow the same method in detail. It seems to be the practice to subject the kernels to a preliminary grinding in order to reduce them to a granulated condition. This may be done with special grating machines or by passing the kernels through corrugated rolls (fig. 6). The kernels thus prepared, together with a portion of the sugar, are then passed through a similar machine with smooth rolls (fig. 7), and after the proper degree of fineness has been attained the mass is mixed with water and further quantities of sugar

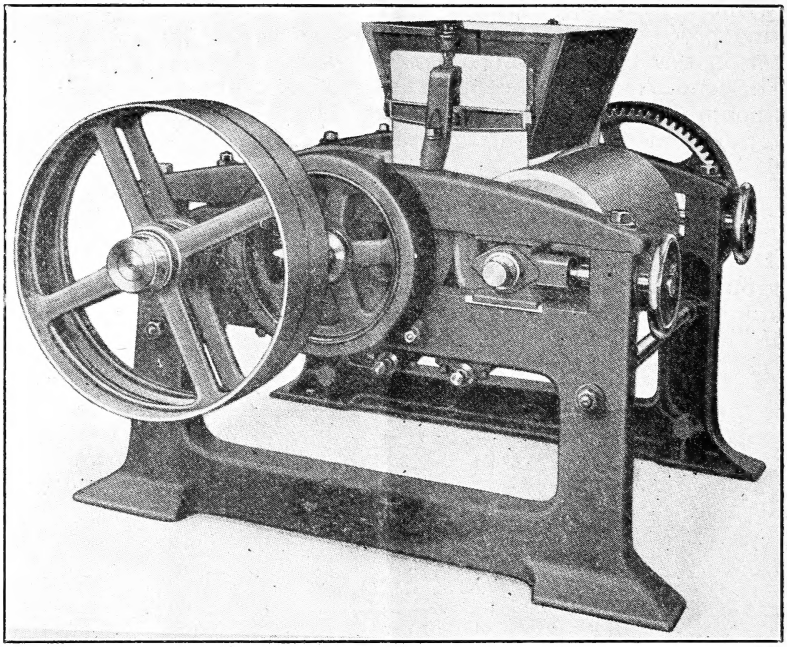

FIG. 6.—Machine with corrugated rolls used in the manufacture of almond paste

in a mixing machine (fig. 5), which results in a homogeneous paste. A modified method consists in grinding the kernels with the sugar and an excess of water in one operation.

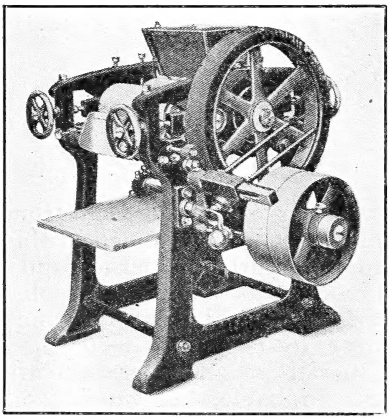

FIG. 7.—Machine with smooth granite rolls for grinding almond paste

The paste is then cooked in steam-jacketed copper kettles fitted with scrapers (fig. 8) to prevent it from adhering to the sides of the kettle. This process serves to make the product still more uniform and reduces the moisture content to the point desired.

Since both the grinding of the mixture and the stirring to which it is subjected in the cooker effect a thorough mixing, the additional treatment in the special mixing machine is probably dispensed with in some cases. After cooking, the paste is cooled while being stirred and is then immediately packed in containers of various sizes according to the demand of the trade. A limited quantity is packed in 1-pound sealed tins, but most of it is placed in large cans or pails for the bakery and confectionery trade. It is not possible to state how much is used directly by housewives, but the quantity is no doubt very small. In other words, almond paste at the present time finds only a limited sale in the retail trade.

Analyses were made of a number of samples of almond paste purchased in the open market, and the approximate composition of these pastes is given in Table 1.

TABLE 1.—*Approximate composition of almond pastes purchased in the open market*

Sample	Moisture	Fat		Free fatty acids in extracted fat	Reducing sugar	Total reducing sugar after inversion (as dextrose)	Ash
		Original sample	Moisture-free basis				
No. 1 ..... per cent	12.78	30.50	35.40	2.22	3.13	37.2	1.024
No. 2 ..... do	16.53	25.03	29.14	9.40	10.01	35.8	.652
No. 3 ..... do	10.65	33.02	36.56	.81	3.13	35.6	1.580
No. 4 ..... do	14.30	32.04	35.27	.98	3.54	32.6	1.680
No. 5 ..... do	11.54	27.08	30.23	1.50	6.44	34.3	1.580
Average	13.16	29.53	33.32	[1] 1.38	[1] 4.06	35.1	1.303

[1] Sample No. 2 was not included in this average, because it was exceptionally rancid and was apparently not a representative sample of such pastes as are generally found on the market.

According to Table 1 commercial almond paste consists of ground blanched almond kernels, sugar, and water, the proportions of which differ somewhat in the several pastes analyzed. The approximate average composition appears to be about 13 per cent water, 35 per cent sugar, and the remainder ground almond kernels. Since the nuts themselves contain about 5 per cent of moisture, the actual quantities of ingredients as mixed would be approximately 57 parts of blanched kernels, 35 parts of sugar, and 10 parts of added moisture, which is equivalent to 55.9, 34.3, and 9.8 per cent, respectively. In examining the pastes used in these analyses, it was observed that sample No. 3, which contained less moisture and more kernels than the average of all the samples, was the best, not only from the standpoint of appearance, taste, and quality of the macaroons made from it, but also from the standpoint of keeping qualities.

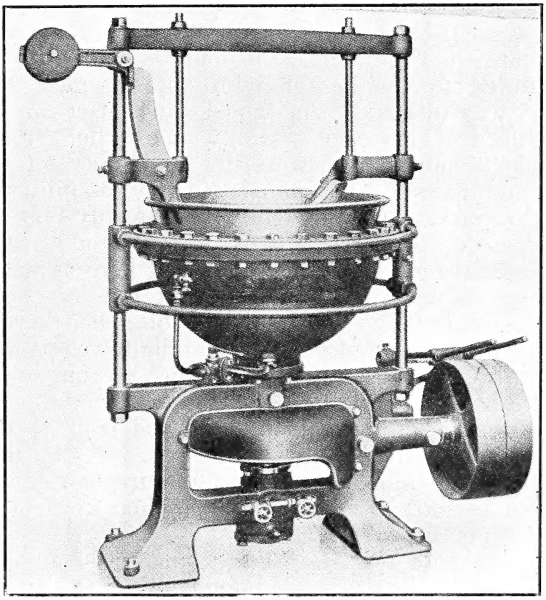

FIG. 8.—Kettle for cooking almond paste. The bowl is made of copper, with scrapers to keep the paste scraped from the sides. It is iron jacketed and can be used for heating the paste with steam and subsequently for cooling it with cold water

INFLUENCE OF MOISTURE CONTENT ON THE QUALITY OF ALMOND PASTE

In making macaroons from almond paste, sugar is first incorporated into the paste, and the resulting granular mixture is then worked into the beaten white of egg. The product thus prepared constitutes the macaroon dough, the physical character of which is of prime importance. It should be relatively stiff; that is, it must not run or spread to any extent when placed in small batches in the baking pan. Dough which does not fulfill this condition is a failure. If the dough is too thin it can be corrected to a limited extent by adding more of the paste, but this is true only when the thinness is due to an improper ratio of paste to white of egg. The factors which determine the behavior of the paste in the dough are of the greatest importance and must be thoroughly understood to insure the preparation of a satisfactory paste.

Many samples of paste were prepared in the laboratory from a supply of almonds that had been blanched for some time, but in every case the result was a thin dough. The proportions of the several ingredients—the ground kernels, sugar, and water—were varied, and small quantities of glucose, starch, gelatin, tragacanth, gluten, and dextrin were added to stiffen the dough, but to no effect. In general appearance and analysis the pastes were entirely satisfactory, but immediately on adding them to the beaten white of egg the latter seemed to thin out and the dough became too thin to retain the macaroon form when baked.[1] Almonds of other varieties were then blanched and made at once into paste. This paste when added to the beaten white of egg gave very satisfactory results. It was observed that the kernels used in the first experiment produced a very pasty, sticky mass when ground, while the new samples when ground were dry and flaky and could be crumbled with the fingers. This pointed to the possibility that it might be a question of variety, but trials with freshly blanched samples of the same variety as that first used gave good, satisfactory paste. When comparing the freshly blanched kernels with those used in the first experiments it was noted that the latter were much more brittle. Therefore some of the earlier blanched kernels were placed in a bell jar over a dish of hot water and allowed to stand for a period of about 16 hours, after which they were no longer brittle but resembled the freshly blanched kernels. When ground the product was flaky and crumbly, and the paste prepared from it was satisfactory in every way. Evidently the kernels used in the first experiments were deficient in moisture, their moisture content being only 2.6 per cent, while that of the freshly blanched kernels of the same variety was 4.4 per cent.

In order to obtain additional proof on this point a further quantity of kernels was blanched and a portion made into paste. A second portion was dried in an oven until the kernels were quite brittle. Of this dried portion half was cracked and placed in a humidor overnight. These two samples were then ground and made into paste. Table 2 summarizes the moisture content and shows the effect of this treatment on the behavior of the pastes made from the several samples.

[1] The writers hereby acknowledge the valuable suggestions and assistance furnished by the Experimental Kitchen of the Bureau of Home Economics in connection with the baking tests of the almond pastes.

TABLE 2.—*Effect of moisture content of almond kernels on the behavior of the paste in macaroon dough*

Sample	Treatment	Moisture content	Character of ground kernels and behavior of paste
		Per cent	
No. 1	None; only surface moisture from blanching removed with fan.	4.84	Ground kernels crumbly; dough satisfactory in every way.
No. 2	Blanched kernels dried overnight in oven at 70° C. (158° F.).	1.28	Ground kernels pasty and smeary; dough very thin.
No. 3	Kernels from sample No. 2 cracked coarsely and kept in humidor overnight.	5.84	Ground kernels crumbly; dough exactly like that from sample No 1.

From Table 2 it is evident that the thinning action of the paste on the white of egg is inherently related to the moisture content of the kernels themselves. The kernels used in the experiments which resulted in faulty paste had been blanched about four months previously and kept in glass jars. Consequently, they were thoroughly dried out, and apparently it was the drying that effected changes in the character or in the proportion of the constituents of the kernels which accounted for the peculiar behavior of the paste. Furthermore, it is not merely a question of the moisture percentage carried into the paste by the kernels, since by adding more water to the paste itself the behavior in the dough is not improved. On the other hand, if the necessary moisture is first restored to the kernels before grinding, as in the case of sample No. 2 in Table 2, the behavior of the kernels is evidently restored to normal. Further evidence may be found in the fact that loss of moisture from the paste itself when it stands in an open container does not give the peculiar thinning effect to the dough that has been described.

The importance, therefore, of moisture control in the blanched nuts can hardly be overestimated. The necessity for maintaining the moisture percentage within a range of 2.5 to 6.5 per cent can be readily appreciated. The general appearance of the paste is no criterion as to what its behavior will be when made into dough, and it is conceivable that without this control of moisture large quantities of unsatisfactory paste could be prepared from overdried kernels and get into the trade with results that would be quite harmful to the manufacturer. Excessive drying at an increased temperature immediately after the kernels have been blanched or a slow gradual drying out of blanched kernels when stored is apparently certain to bring about this trouble. These forms of drying can be prevented by careful control day by day or by not storing blanched kernels for any considerable time.

In all the later experiments almonds of the California Drake variety which had been shelled at least one year previously were used, but by controlling the moisture content of the kernels after they were blanched no trouble was experienced with the paste. It is evident, therefore, that as long as the kernels remain unblanched no change takes place which affects the physical behavior of the paste even when the kernels are comparatively old.

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ALMOND POWDER

The making of macaroons has not been carried on to any extent in the ordinary household, but has been confined largely to bakers and confectioners, probably because of the difficulty and trouble encountered in preparing the macaroon dough from the paste. With a view, therefore, to a product that could be easily handled by the housewife, almond powder has been developed. This product differs from almond paste in two important features: It contains all the sugar necessary, therefore doing away with the disagreeable operation of mixing sugar into the paste with the fingers; it has only about 2 per cent of moisture, whereas the paste contains from 10 to 15 per cent, making a sticky, pasty mass to handle. Almond powder is dry, somewhat granular, can be readily poured from the package, and the only operation necessary to make the macaroons is to beat the proper number of whites of eggs in a bowl, mix in the required quantity of almond powder with a spoon, and bake. Trials made in several kitchens have demonstrated the ease and simplicity with which macaroons can be made from this powder.

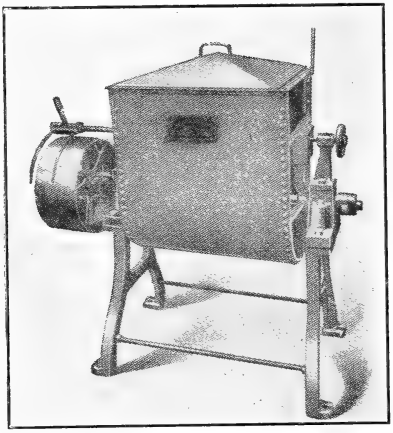

FIG. 9.—Machine for mixing the ground almonds, sugar, and flavoring in the preparation of almond powder

METHOD OF MAKING ALMOND POWDER

After many experiments the following method has been adopted for making almond powder:

The blanched and ground kernels are placed in the mixing machine (fig. 9) with confectioners' sugar, at the rate of 62 per cent of kernels to 38 per cent of sugar, and thoroughly mixed. To this is added, in the same mixer, confectioners' sugar at the rate of 43 per cent of sugar to 57 per cent of the mixture. As in the manufacture of the paste, the addition of a small quantity of oil of bitter almonds free from hydrocyanic acid is necessary. A pound to approximately 375 pounds of the powder is found to impart the proper flavor. Bitter-almond kernels when substituted for the oil were found unsatisfactory, since the flavor imparted was harsh and the product had a distinctly bitter taste.

After the ingredients have been mixed it may be desirable to pass the material through a sieve having about 20 meshes to the inch, which will give it a very uniform appearance. But if the kernels have been ground to a fine uniform texture with no coarse particles and incorporated thoroughly with the sugar this procedure will not be necessary. The powder is now ready to be put in packages.

It will be observed that the manufacture of almond powder is much more simple than that of almond paste. The ground kernels mix readily with the sugar, and the only apparatus necessary is a kettle in which the two ingredients can be thoroughly stirred and tossed about. No kneading, cooking, or pressure is required. It may be that in actual factory operations it will be found practicable to add both portions of sugar at one time and grind them with the kernels. This would eliminate the necessity of first passing the sugar through sieves or bolting apparatus to break up small lumps that are not reduced by the simple stirring action in the powder mixer. Laboratory experiments have shown that ordinary granulated sugar gives a gritty character to the powder. It is probable, however, that by passing the sugar through the granite rolls with the kernels it will be made sufficiently fine to remove this objection. If factory trials prove this to be the case, the cost can be somewhat reduced by substituting granulated sugar for confectioners' sugar.

The physical character of the almond powder is such that it can be marketed either in paper cartons or in friction-top cans. A carton 2⅛ by 4 by 6 inches or a quart can will hold 1 pound of the powder, and these would probably be convenient sizes for the retail trade. A pound of the powder requires approximately the whites of three eggs. The character of the product appears to remain unchanged for an indefinite time, and it would not be necessary, therefore, to use the entire contents of a package at one time if not desired.

The low moisture content of the powder gives it a distinct advantage over the paste, since it makes it less subject to spoilage. Molds do not grow on it, as shown by inoculation tests. There is no added moisture present the evaporation of which might change the character of the powder, as is the case with commercial pastes, which become dry and tough if not kept in tight containers. The sugar remains unchanged and acts as a preservative. The ground kernels remain in better condition and have less tendency to become rancid because of the absence of moisture. That moisture tends to accelerate the formation of free fatty acids in the oil from the kernels is shown in Table 1, where the oil obtained from the sample which had 10.65 per cent of moisture showed only 0.81 per cent of free fatty acids, whereas the oil from the sample containing 16.53 per cent of moisture showed 9.4 per cent. There is no information regarding the age of the several samples, since they were bought in the open market, and the extent to which this factor had affected the composition of the pastes as regards the percentage of free fatty acids can not be stated.

TESTS OF THE KEEPING QUALITIES OF ALMOND KERNELS, ALMOND PASTE, AND ALMOND POWDER

In connection with the experiments on the preparation of almond paste and almond powder some tests were made with regard to the effect of various factors on the growth of molds on these products. It is recognized that in the manufacture of such products it is impossible to keep mold spores from entering the product. The packages are not sterilized, and spores are very liable to be present, especially if the nut cleaning and shelling units are housed in the same building.

The proteins in the kernels are a favorite medium for the growth of molds under certain conditions. Apparently the particular mold which grows on almond kernels and almond paste is *Aspergillus repens.*[2] Table 3 gives the results obtained from inoculating ground unroasted almond kernels of varying moisture content with the spores of this mold.

TABLE 3.—*Results of inoculating ground blanched almond kernels with spores of Aspergillus repens*

Sample	Variety and character	Moisture	Condition of mold after four weeks
		Per cent	
No. 1	California Drake (had been blanched several weeks).	5.80	Very slightly molded.
No. 2	Same as sample No. 1, but with moisture restored in humidor.	9.61	Heavily molded; mold in advanced stage, indicating rapid growth.
No. 3	Valencia (freshly blanched)	7.11	Molded more heavily than sample No. 1, but much less than sample No. 2.
No. 4	Portuguese (bitter taste and bitter-almond flavor).	6.81	No mold.

From Table 3 it appears that in the first three samples the extent of the molding was in proportion to the moisture present in the kernels. Sample No. 4 did not mold, although it contained more moisture than sample No. 1. The reason for this is not apparent. The nuts used for sample No. 4 were bought in the open market under the name "Portuguese." The kernels contain amygdalin, as evidenced by the fact that they develop a bitter-almond odor and taste when macerated with water. The ground kernels, however, have no odor of bitter almonds.

In view of the apparent relation of moisture content to the growth of this mold on almond kernels, tests were made to determine its relationship to the keeping quality of almond paste and almond powder. The results of these tests are given in Table 4.

A study of Table 4 leads to the conclusion that moisture is quite necessary to the growth of *Aspergillus repens* in almond products. It will be noted especially that added moisture is much more conducive to its growth than moisture introduced with the kernels. Thus, samples Nos. 1 and 3 differ considerably in moisture content, but neither contained added water, and no mold growth was noted during the month of observation. All the samples to which water was added showed mold growth except No. 6, which was cooked and much of the added water removed. It seems logical to conclude, therefore, that almond powder which contains no added moisture should be entirely free from the growth of this mold.

[2] The writers hereby make acknowledgment of the helpful suggestions and assistance of Dr. Charles Thom and Miss M. B. Church, of the Mycological Laboratory, Bureau of Chemistry, in connection with the studies on the molds of almond products.

TABLE 4.—*Influence of moisture content on the growth of Aspergillus repens in mixtures of almond kernels and sugar*

Sample	Composition [1]	Moisture [2]	Observation on condition [3]	
			November 22	December 5
		Per cent		
No. 1	Kernels and sugar [4]	1.15	No growth	No growth.
No. 2	Portuguese kernels and sugar	2.30	do	Growth beginning.
No. 3	Kernels and sugar	4.46	do	No growth.
No. 4	Same as sample No. 1 plus 6 per cent water.	7.58	do	Growth beginning.
No. 5	Same as sample No. 1 plus 12 per cent water.	12.77	Growth started	Badly molded.
No. 6	Same as sample No. 5, but cooked 2 hours.	6.80	No growth	No growth.
No. 7	Same as sample No. 3 plus 12 per cent water.	15.62	Badly molded	Advanced stage of molding.

[1] Blanched California Drake kernels were used in all samples except No. 2.
[2] The kernels in samples Nos. 1, 4, 5, and 6 were dried in an oven after blanching. Their moisture content was 1.89 per cent. The kernels in samples Nos. 3 and 7 were not oven dried, and their moisture content was 7.23 per cent.
[3] Inoculations were made on November 8.
[4] In all cases confectioners' sugar was used in the ratio of 38 parts of sugar to 62 parts of kernels

Almond powder can be marketed in paper cartons lined with moisture-proof paper, or in friction-top tin cans. This statement is based on conclusions drawn from a study of several types of packages. Samples of the powder which had been tested and found satisfactory in every way were placed in three types of packages. One was a plain pasteboard box with the usual slip cover. Another was a similar box lined and covered with waxed paper, the seams being sealed with paraffin. The third was a tin can with friction top. After 2½ months the powder from each package was made into dough with the white of egg and each was found to be very satisfactory. The bitter-almond flavor, however, had disappeared from the contents of the unsealed box, but seemed to have retained its full strength in the other two packages. It is evident, therefore, that almond powder does not readily undergo changes that affect its behavior in the dough, but in order that it may retain the flavor of the oil of bitter almonds it is essential that it be packed in well-sealed packages.

PARTIAL COST ESTIMATES OF ALMOND PRODUCTS

It is the purpose to present here estimates of certain costs in connection with the marketing of the several almond products. For purposes of convenience the costs may be considered under the following general heads: (1) Raw material, (2) containers and packages, (3) manufacturing equipment, (4) labor and power, and (5) overhead charges.

From the information available none of these cost items can be definitely determined, but some of them can be estimated with a fair degree of accuracy.

RAW MATERIAL

The item that will fluctuate perhaps more than any other is the cost of the almonds. No definite figure can be given for this, since the cost of production, the market conditions, the source, and the variety used will vary from year to year. However, it is possible to

indicate the quantity of nuts required for a unit pack of the individual products, and from this can be determined readily at any time the approximate cost of the materials for each product on the basis of the prevailing price of the raw material.

It is generally estimated that 100 pounds of almonds in the shell yield about 33 pounds of kernels. Blanching generally entails a loss of about 10 per cent; hence, it may be assumed that 3⅓ pounds of unshelled nuts will be required to supply 1 pound of blanched kernels. From this it follows that the cost of 1 pound of blanched kernels, not including the cost of shelling and blanching, is approximately 3⅓ times the cost of 1 pound of unshelled nuts.

The salted almonds and almond butter consist almost entirely of almond kernels so far as weight is concerned, since only very small quantities of other ingredients are added. Consequently, the capacity of the finished package represents very nearly the quantity of raw material required. The other almond products contain a considerable percentage of sugar and therefore require less of the kernels per unit package.

The quantities of the various ingredients required for the several products are shown in Table 5.

TABLE 5.—*Quantities of the various ingredients required for 100 pounds of the several almond products*

Product	Material required for 100 pounds of the finished product				
	Ingredients other than flavoring (pounds)				Oil of bitter almonds (ounces)[1]
	Blanched kernels	Unshelled nuts	Sugar	Salt	
Salted almonds	98	326.6	----------	2	----------
Almond butter	98	326.6	----------	2	1.1
Almond confection [2]	39.7	132.3	45.7	1.0	1.1
Almond paste [3]	55.9	186.3	34.3	----------	5
Almond powder	35.34	117.8	64.66	----------	3.5

[1] The small quantity of oil required is in addition to the 100 pounds of other ingredients.
[2] The remainder of the 100 pounds is obtained by the addition of water or fixed oil of almonds.
[3] The remainder of the 100 pounds is obtained by the addition of water.

From Table 5 the cost of the raw material required for the several products may be readily estimated if the unit cost of the various ingredients is known. In estimating the quantity of nuts allowance is made for the average loss incident to shelling and blanching, but no allowance is made for any grading of the blanched kernels that may be necessary in the preparation of salted almonds, for which only whole uniform kernels are used. There will be no actual loss, however, due to any sorting or grading, since the off sizes and chips can be utilized in the manufacture of other products.

CONTAINERS AND PACKAGES

In estimating the cost of the packages and containers it has been assumed that the salted almonds and almond butter will be packed in vacuum-sealed glass jars of three sizes, the confection and paste in 5-pound tin cans, and the powder in 1-pound paper cartons or

1-quart friction-top cans. The approximate cost of these several containers is given in Table 6.

TABLE 6.—*Cost of unit packages and containers and their cost per 100 pounds of finished product*

Product	Glass jars [1] with lithographed covers, labels, and shipping cases						Cans with labels and packing cases		Litho-graphed cartons with moisture-proof lining		Friction-top tin cans with litho-graphed labels	
	No. 1		No. 2		No. 3							
	Per unit	Per 100 pounds of product	Per unit	Per 100 pounds of product	Per unit	Per 100 pounds of product	Per unit of 5 pounds	Per 100 pounds of product	Per unit of 1 pound	Per 100 pounds of product	Per unit of 1 pound	Per 100 pounds of product
	Cents		*Cents*		*Cents*		*Cents*		*Cents*		*Cents*	
Salted almonds	3.25	$27.80	4.15	$16.60	5.75	$16.42	------	------	------	------	------	------
Almond butter	3.25	14.85	4.15	8.85	5.75	8.76	------	------	------	------	------	------
Almond confection	------	------	------	------	------	------	8	$1.60	------	------	------	------
Almond paste	------	------	------	------	------	------	8	1.60	------	------	------	------
Almond powder	------	------	------	------	------	------	------	------	0.86	$0.86	4.50	$4.50

[1] The jars designated here as Nos. 1, 2, 3 hold approximately 1.87, 4, and 5.6 ounces of salted almonds and 3.5, 7.5, and 10.5 ounces of almond butter, respectively.

It will be noted from Table 6 that the glass containers are by far the most expensive, and the cost is especially high if a small size is used. If the two larger sizes are used the cost of the packages for 100 pounds of either the salted almonds or almond butter is only about 60 per cent of the cost of packing this quantity in the small size. The package charge for 100 pounds of salted almonds is about 90 per cent higher than for almond butter. This is because the jars hold a much less quantity, by weight, of the salted almonds than of the almond butter.

The almond confection and paste, if desired, may be packed in much larger containers than are here considered. For large users of these products, especially of the paste, tin or wooden pails of 20, 50, or 100 pounds capacity could be used, which would no doubt considerably reduce the package cost.

The almond powder may be packed in paper cartons lined with waxed or moisture-proof paper, or in friction-top tin cans. The tin can has the advantage that it can be resealed if only parts of its contents are used at a time. The paper cartons cost only about one-fifth as much as the cans, but the machinery required for the automatic filling and sealing is very expensive and requires much floor space, although the actual cost of operating such machinery is very low. If cans are used machines for filling and labeling are required for large production, but these machines require comparatively small floor space and are not expensive. If it is desired to sell the product in large quantities to bakers and confectioners it would probably be best to pack it like almond paste.

MANUFACTURING EQUIPMENT

The number and types of machines necessary for the manufacture of almond products will depend to some extent on the scale of operations. At first some of these products will probably be made in only

limited quantities, at least until their acceptance by the trade is determined. The installation of large-capacity labor-saving machines may well be deferred wherever possible until a large production is contemplated, since machines of this type can be used economically only when the output of the plant is sufficient to keep them working at nearly full capacity. Furthermore, in small-scale operations the use of hand labor, wherever possible, will lessen the capital investment. Table 7 gives a list of the equipment which will be required for the manufacture of these various almond products. In a few cases the cost figures given are only estimates, but in most instances they are based on actual quotations.

TABLE 7.—*Approximate cost of machinery required for preparing almond products*

Machine	Floor space required (feet)	Capacity	Horsepower required	Requirement	
				For initial operation	After output is greatly increased
Processing tank and screen basket.	3 by 3			$275	
Cold-water tank	3 by 4			50	
Blancher	5 by 8		2	1,600	
Picking table	2 by 12		½	200	
Oil roaster and salter	2 by 10		½	[1] 400	
Vacuum capper	2 by 4	1,500 jars per hour	1	[2] 120	
Labeler	5 by 6	1,800 jars per hour	½		$600
Dry-roasting unit [3]	10 by 18	400 to 500 pounds of shelled nuts per hour.	2	1,500	
Nut-butter mill	2½ by 4	600 to 800 pounds per hour	5	500	
Confection and paste mixer	5 by 5	30 gallons per charge	3	[4] 1,180	
First paste grinder	5 by 6		1½	800	
Second paste grinder	3½ by 4½		¾	500	
Paste cooker and cooler	3½ by 5	300 pounds per hour	1	375	
Almond powder mixer	2 by 4	250 pounds per hour	2	125	
Carton sealer and liner [5]	6 by 60	1,800 packages per hour			17,000
Can filler for macaroon powder [6]	2 by 3	20 cans per minute	½		325
Labeler for cans [6]					630
Auxiliary equipment, such as conveyers, spouts, elevators, and scales.				[5] 5,000	
Total			20¼	12,625	
Interest on investment (6 per cent)				757.50	
Maintenance and depreciation (10 per cent)				1,262.50	
Total per annum				2,020.00	

[1] Estimated.
[2] The machine is leased at a yearly rental of $50. The $120 charge covers the cost of a vacuum pump, which must be purchased.
[3] This includes elevator, cooler, and fan.
[4] Two of these machines must be installed at $590 each.
[5] This machine is not required if the powder is packed in cans.
[6] These machines are not required if the powder is packed in cartons.

With the exception of the labelers, the carton sealer and liner, and the friction-top can filler, all the equipment listed in Table 7 must be installed in order to begin the operation of the plant. Some of the machines probably can not be operated at their full capacity unless others are installed in multiple units. For example, the output of all the products is determined entirely by the capacity of the blanching apparatus, since all of the nuts used for the several products must first go through the blancher. If, therefore, the production were to be increased to any extent it would be necessary to increase this part of the equipment. It will be observed that the cost of the

carton filling and sealing machine is greater than the combined cost of all the other machinery. The labeling machines intended for labeling the salted-almond and almond-butter packages and the friction-top cans are relatively cheap, and although they are not included in the list for the necessary initial equipment their installation would increase the total cost so slightly that they might well be included. These machines as a rule label the packages much more neatly and uniformly than can usually be accomplished by hand labor.

LABOR AND POWER

The cost of the labor involved in the manufacture of these products can not be estimated with any degree of accuracy at this time. The personnel required to operate a plant as here described will depend largely on the completeness of the equipment installed. As a rule, one person is required for each of the machines. If hand operation is substituted for some of the automatic machinery a greater number of workers of course will be necessary. The hand labor involved in sorting and cleaning the nuts at the picking table will also depend somewhat on the extent to which screens and reels could be utilized for the operation. Although in most cases one person is required to operate each of the several machines, some of the operations require attention only at certain intervals, and one person could probably take care of several such operations. As an example of this type of operation may be mentioned the mixing of the paste, the confection, and the powder. The machines used for this purpose are charged and discharged at regular intervals, and the extent to which these operations could be coordinated would largely determine the labor requirement.

The entire equipment can be operated by electric motive power, and most of the machines are equipped with individual motors. The power requirement, exclusive of that for the carton sealer and liner, is approximately 20 horsepower, which is equivalent to about 20 kilowatts. Steam will be required for the processing kettle and for the paste cooker. The best fuel for use in connection with the roasters is probably gas, but if this is not available the machines should be equipped with electric heaters.

OVERHEAD CHARGES

The overhead charges include taxes, insurance, supervision, advertising and selling costs, and general office expenses. None of these items can be even approximately estimated, because too many factors are involved. Much will depend on the character of the business organization which undertakes the manufacture of these products. The scope and nature of the advertising which is always necessary to introduce new products can hardly be determined in advance, and the selling organization that must be developed is subject to factors and conditions that can not readily be forecast. No attempt, therefore, is made to estimate the cost of the several items included in overhead charges, but it may be stated that in the manufacture of products of this nature these charges no doubt constitute at least 25 per cent of the total cost of production.

DESCRIPTION OF FACTORY EQUIPMENT REQUIRED AND METHODS OF PREPARING ALMOND PRODUCTS

The commercial manufacture of the products described in the foregoing pages proceeds along three main lines, all of which require blanched almonds as the principal raw material. The several lines are briefly as follows: (1) Oil-roasted kernels, yielding salted almonds; (2) dry-roasted kernels, yielding almond butter and almond confection; and (3) unroasted kernels, yielding almond paste and almond powder. (See fig. 1.)

In planning the layout of the equipment (fig. 10) it was not the purpose to outline the only practical scheme of arrangement or to

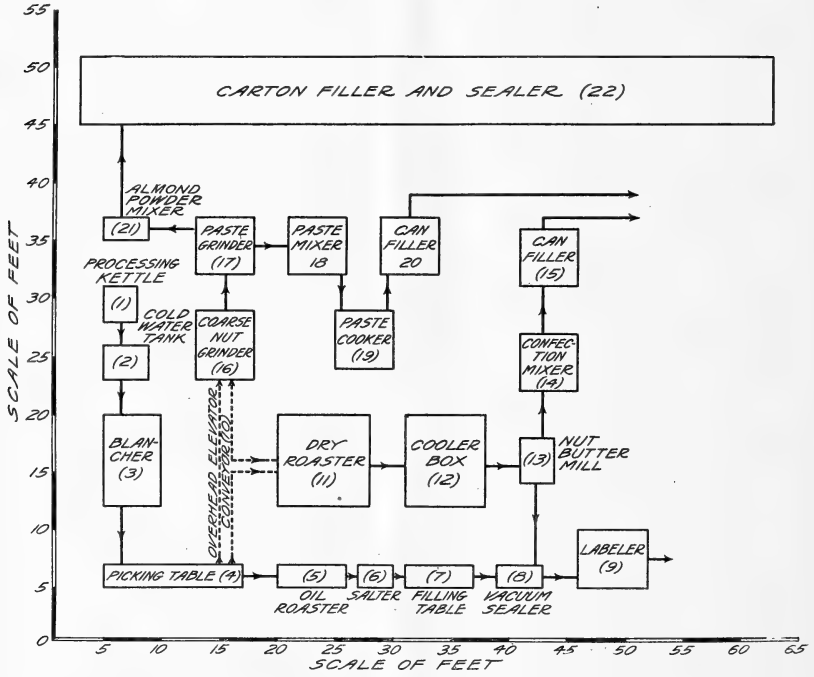

FIG. 10.—Suggested arrangement of the machinery and equipment for the manufacture of almond products

furnish a definite working plan, but merely to show one working plan which, it is believed, will indicate approximately the floor space required and show the flow of the materials through the plant from their entry at one side to the concentration of the several products in packages at the opposite side.

It is assumed that the nuts will be shelled, cleaned, and graded on a floor apart from the manufacturing floor, and thence delivered to the manufacturing floor either by elevator or through spouts convenient to the processing kettle (1).[3] This kettle is a tank in which water can be kept scalding hot either by means of a steam jacket or steam coils. The kernels are placed in a perforated metal basket and lowered into the hot water by means of a convenient tackle

[3] The numbers in parentheses under this heading refer to the individual machines as given in Figure 10, which should be consulted in connection with this description.

which operates on a suspended track. After remaining for several minutes in the hot water the basket is removed, carried along the track, and lowered into the cold-water tank (2). This chills the kernels and facilitates the removal of the skins. The kernels are then drained and dumped into the overhead hopper of the blancher (3) or into a floor hopper if the blancher is equipped with an elevator (fig. 2). Several makes of blanchers are on the market, all of which operate on the same principle, namely, that of passing the processed kernels between rubber rolls which squeeze off the loose skins. The capacity of these machines is determined by the length of the rolls. One type of machine has two sets of rolls, one above the other, thus securing double capacity without increasing the floor space.

In the process of blanching, some of the kernels are not entirely freed from the skins, and others are broken. This is due largely to the lack of uniformity of the kernels. The present available machinery does not operate satisfactorily on mixed sizes of kernels. Either the small ones escape blanching or the large ones are broken. It is important, therefore, that the kernels be graded as thoroughly as possible before being placed in the processing kettle. Even with the more uniform size the blanching will not be perfect, and it is probably safe to assume that at least 10 per cent will be either broken or imperfectly blanched. Consequently, it is necessary to submit the nuts to careful hand picking as they come from the blancher. The picking table (4) is an arrangement whereby the kernels are moved along slowly on a wide belt, the pickers being seated at both sides of the table. All discolored or otherwise undesirable kernels are removed and the unblanched kernels are returned for a second passage through the blancher. As they leave the table the kernels may pass into one of two distinct lines, the requirements of which are different, and a still further separation must be made. Those intended for salted almonds must be whole and uniform, while those which are to be ground, whether roasted or not, may include the off sizes, split kernels, and chips. This separation can be made either by means of rotary sieves, which will separate the uniform kernels, or by hand picking, with perhaps two parallel moving belts instead of one at the picking table, one leading to the salted-almond line and the other to the ground-kernel products.

The large whole kernels pass from the picking table to the oil roaster (5), where they are heated in a vegetable oil to the desired roasted stage. They are then drained and allowed to stand until the surface oil is entirely absorbed, after which they pass through the salter (6). After salting, they are placed in glass containers. This can probably best be accomplished by hand, and for this purpose a filling table (7) is provided. The arrangement and installation of the roaster (5), the salter (6), and the filling table (7) may be carried out according to individual ideas, and all or most of the equipment can be devised and constructed by a competent mechanic.

The filled glasses are then passed to the vacuum capping machine (8). This machine seals the glasses under vacuum and may be used for glasses of various sizes. Since it has a capacity of 1,500 containers per hour it is possible to utilize it in connection with both salted almonds and almond butter. Should there be increased production, there is sufficient space for the installation of an additional machine adjoining the first one.

The question of labeling requires careful consideration. With but a limited output of salted almonds the labeling could probably be done most economically by hand; but, since almond butter will also be marketed in similar packages and will require labeling and since a labeling machine does better and more uniform work, the finished article would present a better appearance if done with the machine (9). Its installation, however, is not absolutely necessary and may be deferred if desired, but in the general arrangement of the other equipment this should be kept in mind.

The second line of products—almond butter and almond confection—starts also from the picking table, where kernels which can not be used for salted almonds, or even the entire output from the blancher if desired, are diverted at right angles to an overhead conveyer (10). From the conveyer they are conducted to the dry roaster (11), which is a machine of the type used for roasting peanuts (fig. 3). It can be equipped with either gas or coal burners. The cooling pan (12) into which the kernels are dumped to be cooled is operated in connection with the roaster. This pan has a perforated bottom and an air stack, and rapid cooling is accomplished by drawing air through the kernels by means of a special fan attached overhead.

When sufficiently cooled the kernels are dumped from the pan into a hopper located beneath the floor and then elevated to the nut-butter mill (13), where they are ground into a smooth homogeneous mass (fig. 4). If the product is to be flavored with oil of bitter almonds this can be added gradually when the salt is added. These mills are equipped with adjustable salting devices, so that the product as it emerges from the mill is the finished butter. From this mill it is packed directly into the glasses and sent to the vacuum capping machine or it is sent in the opposite direction (14) to the confection mixer (fig. 5). If almond confection is to be prepared, less salt is added and more oil of bitter almonds, since the additional sugar which is used in the confection reduces the strength of the flavor. For almond confection the ground kernels are thoroughly mixed in the confection mixer with confectioners' sugar and a small quantity of water or fixed oil of almonds. The finished mass is then dumped out and packed in cans (15). The best method for filling the cans has not thus far been determined. Since the output of a product like almond confection will no doubt be limited and confined principally to the use of confectioners and bakers, it can perhaps best be sold in tin cans holding 5 to 10 pounds. The product could readily be packed by hand and the labeling could also be done economically by hand.

The third line of products comprises almond paste and almond powder. In preparing almond paste the general practice seems to be to give the kernels a preliminary coarse grinding (16) by passing them between corrugated granite rolls (fig. 6). They are then mixed with some of the sugar and passed through a machine (17) with smooth granite rolls (fig. 7) which reduces the mixture to a very smooth paste. Although this is the general practice on a large scale, somewhat similar results can be accomplished on a smaller scale by the use of a small machine which has a device for cracking the kernels before they pass between the rolls, thus combining the two processes in one machine. The ground kernels next proceed to the paste mixer (18), which is the same as the confection mixer. Here water and the remainder of the sugar are incorporated into the mixture, and the resulting paste is passed to the cooker (19), where

it is heated by means of a steam jacket and constantly stirred (fig. 8), scrapers preventing the material from sticking to the sides of the kettle. This cooking is followed by a cooling process, which may be accomplished in the same machine by admitting cold water instead of steam into the jacket. The mass is stirred continuously, and it is practicable at this point to add the oil of bitter almonds for flavoring. The packing and labeling are subject to the same conditions that were described in connection with the packing of almond confection.

Almond powder, which is prepared from the same material as almond paste, requires a mixer (21), which thoroughly incorporates the sugar and oil of bitter almonds with the crumbly ground kernels (fig. 9). It should be packed in paper cartons lined with moisture-proof paper or in friction-top tin cans. If it is to be packed in paper cartons and produced on a large scale it will be necessary to install a filling and sealing equipment (22). Such an equipment places the lining in the carton, weighs the desired quantity of the powder into it, and then seals it. The cartons can be printed in any design desired. If it is desired to have an especially attractive package plain cartons may be used and an additional machine installed to wrap them with finely lithographed wrappers. If the powder is packed in friction-top tin cans, the filling and sealing equipment will be replaced with one machine that automatically fills the cans and another that labels them. In this case considerably less floor space will be required.

According to Figure 10, in which the various items of equipment are indicated with relation to the floor space required, the layout as presented can be placed in a space measuring 55 by 65 feet. In such space there will be sufficient room for boxing the packaged goods if desired and also for a gravity conveyer, by means of which the goods can be sent to the shipping room on the ground floor. Numerous other arrangements of the equipment could also be devised.

If an old building is to be used, the arrangement must necessarily be accommodated to its dimensions. The operations need not all be conducted on one floor. For example, the nut-butter mill could be located immediately below the cooler box, and the machinery for making the paste and powder could be placed below the granite-roll grinder. By this means a building of smaller dimensions could be utilized.

SUMMARY

Certain varieties of almonds are unsuitable for the unshelled-nut trade because they are less attractive in appearance and are less easily shelled than other varieties. They are, however, entirely satisfactory for use in various almond products. Some of these products have been studied in regard to their probable production from domestic nuts. Besides salted almonds and almond paste, several other products which are not now on the market have been specially studied, and formulas are given for their manufacture. The question of their keeping qualities has also received special attention.

Cost estimates of the raw material and the containers required for the various products have been made.

A list of the machinery and equipment required for the manufacture of the various products is given and also an estimate of the cost.

A plan for the arrangement of this machinery in a plant for the manufacture of the products is outlined.

ORGANIZATION OF THE UNITED STATES DEPARTMENT OF AGRICULTURE

June 14, 1924

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